



# **Ambient Noise Statistics for Sonar Modelling – Final Report**

## *A Call-Up Under the Noise Monitoring Software Standing Offer*

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## **Defence R&D Canada – Atlantic**

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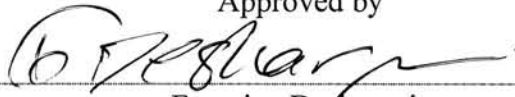
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Author

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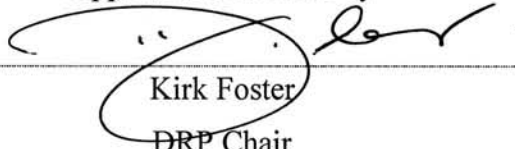


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Francine Desharnais

Scientific Authority

Approved for release by



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Kirk Foster

DRP Chair

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## Abstract

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This report documents the work done to process EC-SWAN sonobuoy data collected monthly over a 12-month period in late 1995 and 1996. Nine or more sonobuoys were dropped at each of four sites, and included calibrated Low Frequency Analysis and Ranging (LOFAR), Vertical Line Array (VLA) and Directional Frequency Analyzing and Recording (DIFAR) types. The data were processed to determine statistics for use in synthetic sonar data modelling. The data were processed using 8K Fast Fourier Transforms (FFT) and ~4 second incoherent averages. The data sample rate was 6147.5 Hz. Statistics were then computed for five-minute blocks, and averaged to determine the mean statistic over the one-hour sample time. These data are intended to provide a characterization of the probability density functions for ambient noise in Canadian waters that can be used for input to sonar simulation software.

## Résumé

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Le présent document fait état des travaux effectués sur le traitement des données de bouées acoustiques EC-SWAN (bruit ambiant en eau peu profonde dans l'Est canadien) collectées mensuellement sur une période de 12 mois de 1995 à 1996. Au moins neuf bouées acoustiques ont été jetées à l'eau à chacun des quatre emplacements. Les bouées étaient des types suivants : de télémétrie et d'analyse à basses fréquences (LOFAR), à antenne linéaire verticale (VLA) et de détection et d'analyse directionnelles à basses fréquences (DIFAR). Les données ont été traitées afin d'obtenir les statistiques qui serviront à la modélisation synthétique des données de sonar. Les données ont été traitées au moyen de transformées de Fourier rapide (FFT) 8K et de moyennes incohérentes d'environ 4 secondes. Le taux d'échantillonnage des données était de 6 147,5 Hz. Les statistiques ont ensuite été calculées par blocs de cinq minutes, et la moyenne statistique de l'échantillon a été déterminée sur une heure. Ces données serviront à obtenir une caractérisation des fonctions de distribution de probabilité du bruit ambiant dans les eaux canadiennes, qui peuvent servir de données d'entrée pour le logiciel de simulation de sonar.

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# **Executive summary**

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## **Introduction**

In past years, the underwater acoustics community has shifted focus from the deep ocean to littoral water areas. Working with shallow water acoustics is extremely challenging since the environment can change dramatically in both time and space. Past data collection exercises, such as the Eastern Canada Shallow-Water Ambient-Noise (EC-SWAN) experiment, were undertaken to study the temporal and spatial variation of ambient noise in Eastern Canadian waters. There is now a renewed interest in these statistics, for use in synthetic sonar data modelling.

## **Results**

This contract built a tool to revisit the EC-SWAN dataset to provide a characterization of the probability density functions for ambient noise in Canadian waters suitable for input to sonar simulation software. This tool is essentially an analysis software suite added to the Software Tools for Analysis and Research (STAR). This software package is extensively used at DRDC Atlantic to efficiently process passive and active sonar data. The EC-SWAN processing tool added to the overall capability of STAR.

## **Significance**

This new software package will simplify and expedite the re-processing of the valuable EC-SWAN data, leading to a set of ambient noise statistics that can then be implemented in any synthetic sonar data model. Data of this type are presently unavailable in the open literature, and are essential for the study and development of sonar detection and tracking tools using synthetic data.

## **Future plans**

The results of the data processing will be included in future reports.

Hood, J. and Macmichael, C. 2005. Ambient noise statistics for sonar modelling - Final report. DRDC Atlantic CR 2005-126. Defence R&D Canada – Atlantic.



# Sommaire

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## Introduction

Au cours des dernières années, le milieu de l'acoustique sous-marine a déplacé son champ d'intérêt de l'océan profond vers les eaux des zones littorales. L'acoustique en eau peu profonde présente un grand défi, car l'environnement peut changer de façon dramatique dans le temps et dans l'espace. Des collectes de données antérieures, telles que dans le cadre de l'expérience EC-SWAN (bruit ambiant en eau peu profonde dans l'Est canadien), ont été entreprises pour étudier les variations dans le temps et dans l'espace du bruit ambiant dans les eaux de l'Est canadien. On s'intéresse à nouveau à ces statistiques pour les appliquer dans la modélisation synthétique des données de sonar.

## Résultats

Le contrat en cause a donné lieu à la réalisation d'un outil qui permettrait de réutiliser l'ensemble de données EC-SWAN de façon à obtenir une caractérisation des fonctions de distribution de probabilité du bruit ambiant dans les eaux canadiennes, qui peuvent servir de données d'entrée pour le logiciel de simulation de sonar. Cet outil est essentiellement une suite logicielle ajoutée aux outils logiciels pour l'analyse et la recherche (STAR). Ce progiciel est très utilisé à RDDC - Atlantique pour traiter efficacement les données sonar passif et actif. L'outil de traitement des données EC-SWAN améliore les capacités globales du STAR.

## Portée

Ce nouveau progiciel simplifiera et accélérera le nouveau traitement des précieuses données EC-SWAN, et qui mènera à un ensemble de statistiques sur les bruits ambiants qui pourra ensuite être appliqué à tout modèle synthétique de données de sonar. Les données de ce genre ne sont pas disponibles dans la documentation non classifiée, et sont essentielles pour l'étude et le développement d'outils de détection et de poursuite sonar basés sur les données synthétiques.

## Recherches futures

Les résultats du traitement des données figureront dans les rapports à venir

Hood, J. and Macmichael, C. 2005. Ambient noise statistics for sonar modelling - Final report. DRDC Atlantic CR 2005-126. Defence R&D Canada – Atlantic.

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# 1. Introduction

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This final report outlines the work done under Noise Monitoring Software Regional Individual Standing Offer (RISO) W7707-032293/001/HAL, Call-up Requisition No. W7707-04-2681. This work was performed for Defence R&D Canada (DRDC) – Atlantic under the direction of the Scientific Authority (SA), Francine Desharnais, from approximately December 2004 to March 2005.

## 1.1 Overview

The objective of this call-up was to simplify the calculation and presentation of ambient noise statistics that could be used for input in sonar simulation software. This was done by using generic software components available in the Signal Processing Packages (SPPACS) to batch process raw data, outputting power spectral data incoherently averaged over four seconds. The processed data were also calibrated for processing and sonobuoy gain and stored in DREA .pwr formatted files. A second processing stream was used to compute third-octave averages starting at 6 Hz for the same data. The processed data were then read into Interactive Data Language (IDL) in five-minute chunks, and the mean, median, skew, kurtosis and standard deviation computed for selected frequencies and the third-octave averages. All of these statistics were computed on Log scaled data. These 5-min chunks were then averaged over 12 samples, or as many as were available in each data file, to produce an average statistic. There were usually ten sonobuoys per site with four sites being sampled per flight. The flights occurred over the course of a year from December 1995 to December 1996.

This report is broken into five main sections. The remainder of this section provides background on the software used during the call-up. Section 2 provides an overview of the call-up's software development requirements and work performed to meet those requirements. Section 3 provides an overview of data content. All raw and processed data were copied to a hard drive accessible to the SA. The raw data alone consumed more than 30 GB of storage. Section 4 details software configuration management processes and the versions used for this call-up. Section 5 provides a summary of current software issues. None of the current software issues affect this call-up.

## 1.2 Background

The data processing and analysis work was performed using two software suites: Software Tools for Analysis and Research (STAR) and SPPACS. An overview of the two software suites is provided in the following subsections.

The STAR and SPPACS suites are configuration controlled using the concurrent versioning system (CVS), and issue and enhancement idea tracking is affected using the Bugzilla issue tracking software. CVS is a repository that allows developers to check-in revisions to software and documentation where they are archived in a common database. The tool allows all previous versions of the software to be maintained and aids resolution of new issues, while ensuring that current builds of the software are readily accessible to users and developers alike. Bugzilla is a web accessible database that offers both user and developer input to issues, priorities and solutions. It provides coherent tracking and recording of an issue over its entire lifecycle.

STAR and SPPACS components are documented in a combination of formats, each with their own purpose. Microsoft Word documents are maintained, which describe functionality and algorithms of components. These are primarily intended for the end user. Enterprise Architect (EA) files are maintained, and document software design, interaction and dependencies. EA design information is intended primarily for developers. Hypertext Markup Language (HTML) library documentation is being developed, which provides automatic extraction of the routine's Application Program Interface (API), purpose and description. This documentation is maintained to assist developers in familiarizing themselves with the existing libraries and components, and is intended to support and encourage software reuse. Some users may also wish to refer to this information for use in their own custom applications. SPPACS also provides HTML and man page user documentation for each module.

The most current status of the SPPACS and STAR suites can be found at <https://star.iotek.ns.ca>. Users are also encouraged to refer to the electronic documentation provided with the software distribution for up-to-date information.

### **1.2.1 STAR**

The STAR suite was developed to support general research and analysis objectives at DRDC Atlantic. The primary objectives of the STAR suite are:

- Provide scientific grade analysis tools that allow for efficient, detailed quantitative and qualitative analysis of a data set.
- Support synergy between DRDC groups and the Department of National Defence (DND) by providing a common software base for analysis. This synergy encourages inter-group communication and simplifies user training, analysis process development, documentation and data portability.
- Support cost and analysis efficiency by providing software reuse and common tools and data formats. Examples of efficiency would be using the output of analysis from one group to feed the inputs of another, or using common software components to lower development cost of several custom analysis tools.

All STAR components are currently implemented using IDL, though the design is not restricted to IDL. The name STAR reflects the generic nature of the software. Applications in the STAR suite are built using a combination of reusable and custom components that meet the requirements of each application. The layered design and common components allow for rapid and logical development of new capabilities. Though currently focused on sonar data processing and analysis, the tools are capable of expanding to meet other analysis and research requirements.

### **1.2.2 SPPACS**

SPPACS is a group of software programs that are based on the C programming language and are implemented on Linux-based personal computers (PC). Each program provides a specific processing function and a series of programs can be chained together to create a custom-processing stream using the command line or scripts. The output from SPPACS is stored in DRDC Atlantic formatted data files. SPPACS has slowly evolved to its present day state due to the efforts of several MacDonald Dettwiler and Associates Ltd. (MDA) personnel over the last 4 years.

SPPACS has been used to perform a number of mid-trial and post-trial processing functions, such as the post-trial study of multistatic trial data and the mid-trial analysis of the Q265 sonobuoy test trial. SPPACS only performs data manipulation and does not provide an interface to examine the results. The processed data output is often imported into other applications that enable data display and are used to perform the detailed analysis of the results. One example of such an application is the STAR suite.

The SPPACS software suite consists of two types of software. One type is runtime executables that can be used to process DRDC Atlantic data files in a number of ways, including data management and signal processing. Each program performs a specific function and the programs are designed so that they can be used in conjunction to perform more complex processing tasks. The software has proven to be very useful in simplifying data management and sonar processing tasks by providing a set of tools from which to build the necessary processing streams. These streams can be run from the command line or assembled into scripts to perform batch-processing tasks allowing for large amounts of data to be automatically processed. The second form of the software is a group of library functions that can be used by other programs to efficiently perform standard tasks. These library functions are extensively used by the runtime software, but can also be used for other applications. There are now three types of libraries. The first are utility routines for performing tasks, such as header manipulation and command line parsing. The second are signal processing modules termed Signal Processing Library SPLIB. These are low-level modules, each performing a low level signal-processing task. A new SPPACS module typically consists of one or more SPLIB modules linked together with an SPPACS user interface. The final library type is a sonar processing module termed sonar library (SONLIB). These are more complex modules that combine several SPLIB modules to create a complex sonar module, such as passive processing. Separating the SPLIB and SONLIB modules from SPPACS generated more generically reusable software. SPLIB and SONLIB are independent of the data header format, timestamping method, etc., and are suitable for integration in real-time processing systems.

SPPACS is also supported by a set of signal processing libraries known as the Fastest Fourier Transform in the West (FFTW). These free, open-source libraries provide optimized signal processing functions helping to ensure that the SPPACS software runs as efficiently as possible, while providing a significant reduction in coding effort.



## 2. Work Overview

This section presents an overview of the tasked work and a summary of the work that was completed. The development requirements for this call-up are listed in Table 1. All requirements were successfully completed.

**Table 1. Requirements**

TASK	DESCRIPTION
<b>Task 1: Support Data Processing</b>	The contractor shall support processing of provided trial data to produce LOFARGRAM of the data. This processing will be tuned to provide statistical analyses of the data using algorithms provided by the SA.
<b>Task 2: Requirements Analysis and Design</b>	The contractor shall meet with the SA prior to the implementation to identify which algorithms will be implemented and the level of user interaction required. User interaction will include setting of algorithm parameters, modification of which algorithms are used and modification of which data are passed to the algorithms. (NOTE: The statistical algorithms must also function on a 'headless' system for batch runs.)
<b>Task 3: Implement and Processing Requirements</b>	<p>The contractor shall address the requirements, detailed in the following list, and as prioritized by the SA, by enhancing the STAR Suite.</p> <p><i>Data survey:</i></p> <ul style="list-style-type: none"> <li>- Download data from DLT tapes.</li> <li>- Process power files with settings defined by the SA.</li> <li>- From LOFARGRAMs, identify periods with suitable ambient noise data [~1.25 hr periods]. Annotate period for presence/absence of ship noise or other events.</li> </ul> <p><i>Statistical algorithms:</i></p> <ul style="list-style-type: none"> <li>- Calculate mean and median noise levels, standard deviation, skew and kurtosis for a user-selected intervals [5 min], and a user-determined set of frequencies and bandwidths.</li> <li>- Calculate probability distribution surfaces (probability vs noise level and frequency) for the same intervals. PDFs should be normalized so that: <math>\int_{-\infty}^{\infty} f(y)dy = 1.</math></li> </ul>

**Table 1. Requirements**

TASK	DESCRIPTION
	<ul style="list-style-type: none"> <li>- Calculate the 10, 50 and 90% percentile of ambient noise spectra for the same intervals.</li> <li>- Tabulate above results.</li> <li>- Plot above results on 1 page for a given sonobuoy.</li> <li>- For the entire (~1.25 hr), calculate the overall mean, median, standard deviation, average skewness and kurtosis and decorrelation time.</li> <li>- Tabulate the overall results.</li> </ul> <p>The SA will indicate where algorithm and design review is required and the SA shall approve or provide those algorithms and designs prior to implementation. Algorithms should be designed to allow for an arbitrary choice of processing parameters, such as binwidth, period selection for various statistics, etc.</p> <p><i>Data Processing:</i></p> <p>The contractor shall process a subset of the EC-SWAN dataset, to be provided by the SA. The complete EC-SWAN dataset includes 12 sets of 1 to 1.5 hour over 4 sites (9 sonobuoys/ site).</p>
<b>Task 4: Perform Testing</b>	The contractor shall develop test plans and test the software to the satisfaction of the SA and where possible, automate those tests to allow for rapid regression and installation testing. The SA shall have the option to review tests prior to testing.
<b>Task 5: Software Maintenance and Design Improvement</b>	<p>As required, the contractor will troubleshoot and repair defects in the software.</p> <p>As time permits and as authorized by the SA, the contractor will examine the evolving software design and implement improved design features helping to ensure the long-term viability and reusability of the software.</p> <p>As required and as specified by the SA, the contractor will add enhanced functionality to the software within the limits of the call-up funding.</p>
<b>Task 6: Maintain Configuration Management</b>	The contractor shall implement configuration management of the IDL software using the Concurrent Versioning System (CVS) and provide software deliverables by checking them into CVS and then demonstrating a successful checkout and run.

**Table 1. Requirements**

<b>TASK</b>	<b>DESCRIPTION</b>
<b>Task 7: Track Software Issues</b>	The contractor shall use software issue tracking and resolution management using the Bugzilla issue-tracking tool.  Web-based entry and review of issues from DRDC Atlantic shall be made available to the SA on the STAR Portal web site.
<b>Task 8: Generate Documentation</b>	The following details shall be documented in the contractor report:  a. As implemented algorithms and design  b. Testing performed  c. User interface changes

## 2.1 Data Processing

Data processing requirements were as follows:

- Download data from Digital Linear Tapes (DLT)
- Process power files with settings defined by the SA
- From LOFARGRAMs, identify periods with suitable ambient noise data [~1.25 hour periods]. Annotate period for presence/absence of ship noise or other events.

A number of small changes were made to this task during the call-up.

- It was found that the data were on Exabyte tapes. A tape drive was taken on loan from DRDC and the tapes were transcribed to a removable hard drive with a Universal Serial Bus (USB) interface. This allowed all processed and raw data to be quickly transferred back onto DRDC servers after call-up completion.
- It was decided to process the data using 8K FFTs, 50% overlap, Hanning windows and five incoherent averages. Third-octave processing was to start at 6 Hz. The SA provided calibration files for all buoy types. Two scripts were created to perform power spectra (process\_spectra) and third-octave processing (process\_third\_octave), but they later had to be modified to account for changes in buoy type to recording channel assignments over the flights. This was handled by passing in parameters describing a list of the channels associated to each buoy type, and using the update\_proc script as a master script. All processing scripts can be found in the scripts directory of the trial. All calibration files can be found in the cal\_files directory of the trial.
- During the call-up it was found that a data survey had already been conducted and ‘deleted spectra’ were interpreted to be times with bad data. An option was added to the IDL processing to ignore those spectra in hourly average computation. Regardless, LOFARGRAMs can be viewed in STAR by the SA from the processed .pwr files produced.

## 2.2 Statistical Processing and Output Formatting

Statistics processing requirements were as follows:

- Calculate mean and median noise levels, standard deviation, skew and kurtosis for a user-selected interval [5 minutes], and a user-determined set of frequencies and bandwidths.
- Calculate probability distribution surfaces (probability versus noise level and frequency) for the same intervals. PDFs should be normalized so that:  $\int_{-\infty}^{\infty} f(y)dy = 1$ .
- Calculate the 10, 50 and 90 percentiles of ambient noise spectra for the same intervals.
- Tabulate the results.
- Plot results on a single page for a given sonobuoy.
- For the entire (~1.25 hour), calculate the overall mean, median, standard deviation, average skewness and kurtosis, and decorrelation time.
- Tabulate the overall results.

User frequencies were selected to be 20, 63, 500, 800, 1260 and 2000 Hz. The bins closest to these frequencies were used. It was decided that the .pdf information would only be provided in the plots, but that they would also be available from an IDL structure at run-time for manual analysis.

Using the STAR library of applications, a more generic statistics analysis window application was created to display the results of the ambient noise statistics calculations. This application was written to allow the user to modify their selections at run time without further software development. In the start-up script, the user may define:

- An arbitrary list of frequencies or request all frequencies.
- An arbitrary list of receivers (data channels) or all receivers.
- There is a flag to define whether the frequencies should be calculated using a third octave formula, as there is no distinct definition of third-octave data in a DREA header.
- The time interval in seconds over which to process a data chunk, in this case 300.
- The display spacing for data sets. This is an integer to specify which chunks to use. For example, if set to 5, every fifth processed chunk will be displayed on the summary plots. If set to 1, every chunk will be plotted, though the resulting plots are likely to be very compressed.
- The overall time range to calculate statistics may be set in the start-up script. This can be used to select only a portion of the data.

- The PDF starting level, spacing and ending level may be set.
- The user may also use a set of flags to disable the text file output (tabular summaries), the postscript summary plot output, or the display window.

On execution of the script, all statistics for all data sets of selected frequencies and receivers will be calculated and stored in a memory structure. The output text tables, including overall summary tables and postscript summary plots, are then generated automatically. Finally, the summary plots may then be reviewed individually in the statistics analysis window. Selecting the 'View Next' button displays the summary for the next receiver. The user also has the option to selectively save a plot to a custom Postscript file and suspend the in-memory structure to IDL. This suspend function allows the user to access the in-memory data from the IDL command line, or from a custom script.

Figure 1 shows a sample display window. The following statistics are plotted for the SA selected frequencies for every third chunk:

- Mean
- Standard Deviation
- Skew
- Kurtosis
- PDF
- 10, 50, 90 percentiles from the PDF (Solid, Dotted and Dashed lines, respectively)

The filename, processor channel and time are down in the first plot's title. The remaining plot titles show the time range in minutes from the start of the file that was used to generate the plot.

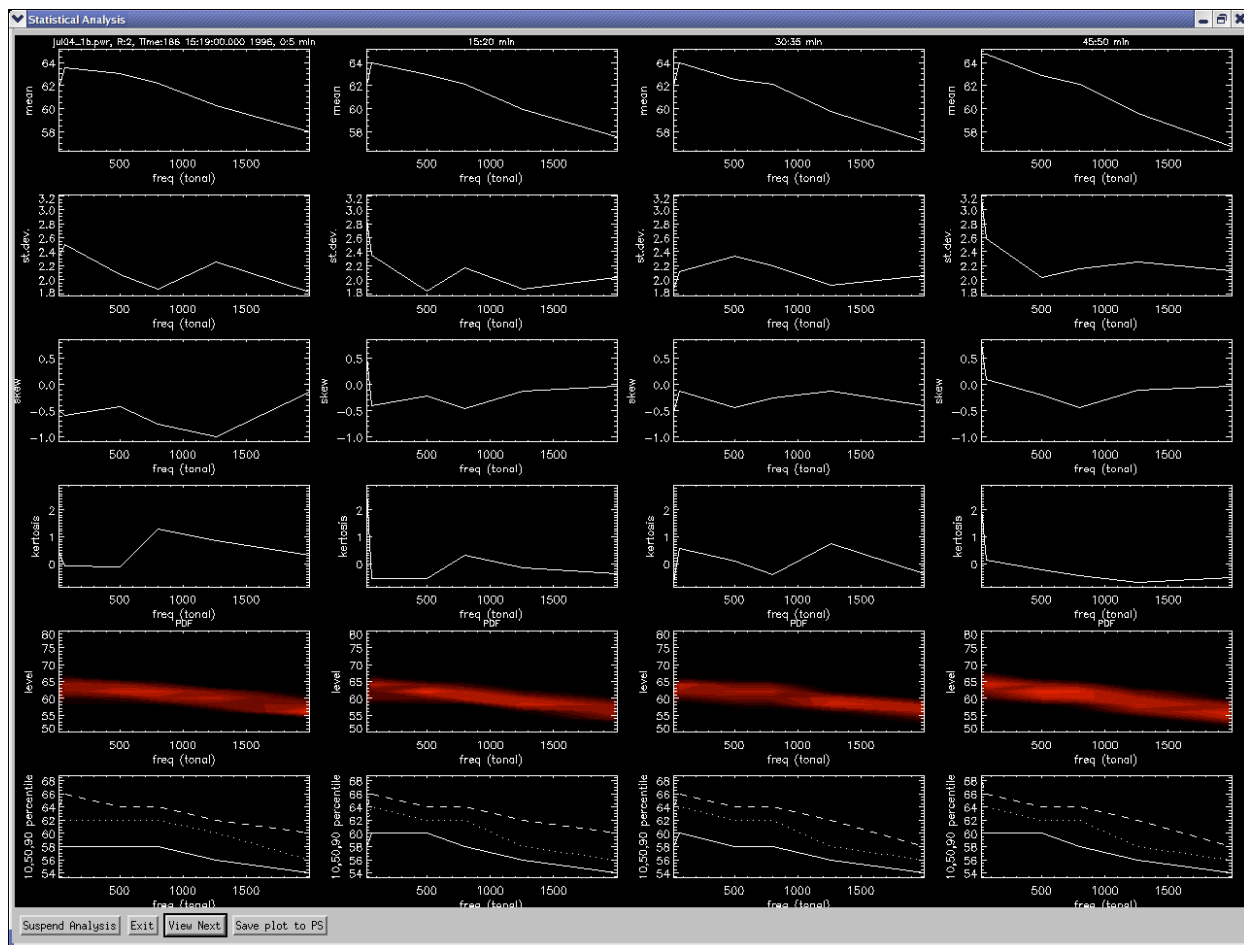


Figure 1. Statistics Analysis Display

The postscript output files are identical to the screenshot, except the PDF is greyscale and the background is white with black text and graphics. A sample of the output tables is shown in Figure 2. They are delimited American Standard Code for Information Interchange (ASCII)-based text files that can be read into applications, such as Microsoft Excel, for custom analysis.

```
#File Created:/opt/ssp/data/ambient_noise/processed/triallomme-
527b/spectra_data/jul04_lb.pwr_noise_stats.txt, on:Wed Mar 30 23:43:32 2005

#Source File:/opt/ssp/data/ambient_noise/processed/triallomme-
527b/spectra_data/jul04_lb.pwr, Data start time: July 4 15:19:00 1996

#Recorder Receiver RF Latitude Longitude
#triallomme-527b 1 OM_N_B 45.500000 -50.000000
#triallomme-527b 2 OM_E_1 45.500000 -50.000000
#triallomme-527b 3 OM_W_1 45.500000 -50.000000

#Frequency(tonal): 20.261671, Beam: 0.0000000

#RF:Receiver Sample Mean Median StdDev Skew Kurtosis
OM_N_B:1 0:5 85.509453 85.462433 3.1743660 -0.82637519 3.0205503
OM_N_B:1 5:10 84.708450 84.999207 2.3486032 -0.35854453 -0.42521572
OM_N_B:1 10:15 85.531601 85.689682 2.0663860 -0.36596778 0.60989571
OM_N_B:1 15:20 85.187042 85.167458 2.7759728 -0.15457967 0.96901655
OM_N_B:1 20:25 85.988091 86.290359 2.5977252 -0.47521719 0.45095468
OM_N_B:1 25:30 85.296471 85.115044 4.3040609 -0.67177862 3.2522545
OM_N_B:1 30:35 69.115372 79.069870 17.151575 0.023129262 -1.9521452
OM_N_B:1 35:40 51.796375 51.903130 0.75303471 -0.15878107 -0.62454915
OM_N_B:1 40:45 51.435127 51.448769 0.67389983 -0.22400841 -0.37052369
OM_N_B:1 45:50 51.585316 51.603889 0.79031360 1.4706811 8.6684132
OM_N_B:1 50:55 51.965252 51.834976 1.6483419 7.8789630 67.763794
#RF:Receiver Sample Mean Median StdDev Skew Kurtosis
OM_E_1 :2 0 :5 61.893429 62.447556 2.3298728 -0.49095577 0.41027117
OM_E_1 :2 5 :10 61.682838 61.855888 2.1217639 -0.45029375 0.061904907
OM_E_1 :2 10 :15 61.743435 62.171509 2.5413525 -0.59235471 0.80893350
OM_E_1 :2 15 :20 62.040924 61.925331 2.8633842 0.54202247 2.7351904
OM_E_1 :2 20 :25 61.718792 61.665970 2.3424962 -0.028601099 -0.0049319267
OM_E_1 :2 25 :30 62.946751 62.900177 2.2354417 0.51447237 0.14676499
OM_E_1 :2 30 :35 62.022194 62.435600 1.8616357 -0.52803302 -0.64442730
OM_E_1 :2 35 :40 62.004192 62.003716 2.4315717 1.3564923 4.3333879
OM_E_1:2 40:45 62.063938 62.227768 2.3041084 0.66160828 2.2344894
OM_E_1:2 45:50 64.687500 64.422134 3.1511843 0.76120478 2.0443554
OM_E_1:2 50:55 63.698215 63.250832 4.3913574 2.0888584 7.4132318
#RF:Receiver Sample Mean Median StdDev Skew Kurtosis
OM_W_1:3 0:5 62.544231 62.447762 2.8860269 0.094522350 0.39098573
OM_W_1:3 5:10 62.055416 62.092567 2.4406767 0.26085782 1.0372601
OM_W_1:3 10:15 61.969933 62.107811 2.0345299 -0.24050899 0.40238070
OM_W_1:3 15:20 61.887089 61.812531 2.2967062 0.36986551 0.83945417
OM_W_1:3 20:25 61.919964 62.133865 2.2541733 -0.081670716 -0.16462708
OM_W_1:3 25:30 61.987724 61.873497 2.4649143 0.23451820 -0.039600849
OM_W_1:3 30:35 61.118908 61.677765 2.3606203 -0.39654845 -0.26389527
OM_W_1:3 35:40 61.949940 61.950729 2.3073370 0.46918571 1.4626527
OM_W_1:3 40:45 61.972298 61.957443 2.6926897 1.3791738 5.1065559
OM_W_1:3 45:50 64.202072 62.588913 5.7590089 1.8694299 3.1886806
OM_W_1:3 50:55 63.774746 62.688965 5.0381756 2.4106739 5.9048653
#Hourly averaged summary data excluding data sets: 12
#RF:Receiver Mean Median StdDev Skew Kurtosis Decorrelation_Time(s)
OM_N_B:1 71.647141 72.598620 3.4803890 0.55795644 7.3965859 12.568514
OM_E_1:2 62.409292 62.482407 2.5976517 0.34858365 1.7762882 19.231341
OM_W_1:3 62.307484 62.121077 2.9577144 0.57904536 1.6240647 14.688505
```

**Figure 2. Postscript Output Sample**

Each tabular output follows the same format. The first line of the file indicates the name of the original output file and the date that the data were processed by IDL. The second line indicates the processed data file used for source data, and the date and time from the source file header. The next group indicates the receivers and their position as entered into the non-acoustic data (NAD) for the trial. In this case, it is the nominal center of the area. The radio frequency (RF) number actually shows the receiver name, as provided by the EC-SWAN team. After this, tabular statistics for each frequency are provided. In this case it is tonal data indicated by the text on the first line. The beam direction is also specified, in case beamformed statistics are desired at a later date. Each receiver's statistics are tabulated, followed by a summary for all receivers at the end of the block. The remainder of the file, not shown, provides tables for the remaining frequencies. An identical output is produced for third octave data, except that the displayed frequency is the center of the third octave band, computed as the sixth octave, and the annotation marks it as such "(1/3-oct band)".

## 2.3 STAR Scripts

STAR applications are generally started using a custom script. These scripts are built from a template provided with the software distribution, and allow users to define a variety of custom processing and viewing options, such as those shown previously. Other generic options, such as font size, can also be set.

Several STAR scripts were provided along with the trial data. A short description of each follows:

- `Stats_anal.pro`: This script could be used to provide an overview of all data. It processes statistics for all frequencies in its current state, so it does take some time to run.
- `Tonal_anal.pro`: This script is used to produce output for each selected tonal frequency. In its current state, it provides a graphical user interface (GUI), postscript output and tabular output.
- `Oct_anal.pro`: This script is used to produce output for all computed third-octave bands. In its current state, it provides a GUI, postscript output and tabular output.
- `Gram_view.pro`: This script launches the STAR `power_spectral` application, which can be used to view LOFARGRAM data. It is useful as it provides a common view of the data that can be used to understand anomalies, such as those that may be caused by close range contacts or aircraft over-flights.
- `Ambient_anal.pro`: This script launches a STAR application designed to view `.pwr` formatted data files from a number of perspectives. For example, you can plot many time records of a single bin or a single time record for all bins. You can also plot a single time-bin point over all receivers. This could be useful for more qualitative analysis of the data.
- `File_dur_an.pro`: This is a simple script that was used to determine the file length for all transcribed files. Its output is shown in section 3.



## 2.4 Software Reuse

The LOFARGRAM viewing and ambient noise analysis tools were not generated as part of this call-up but were available for use because of the common approach taken in executing this call-up. This is a direct example of the utility of selecting a common set of analysis tools and building on them for custom analysis requirements.

Other capabilities used during this call-up also came from reusable components generated during other call-ups. Without these, it would have been impossible to provide an application with a structure as seen here. Instead a “one-of” script would have been required that only met the contract requirements and did not support further re-use. Some of the reusable components used include:

- **DRDC\_file\_io / Power\_data:** Several libraries of functions designed to read segments of data from DREA formatted data files, handle header formats, etc.
- **Time:** A simple library to handle manipulation and formatting of time based data. It also includes utility functions to convert to and from text, and DREA header formats.
- **Tactical\_database:** This is the component that was used to parse, store and provide query access to receiver names. It allowed the application to run generically and simply fill in this data, as required.
- **Position\_model:** This application caches currently displayed or otherwise required receivers for quick access.

These modules also have other capabilities that were not used during this call-up, and still more modules are developed and tested so that they can be used in other work.

## 2.5 Further Information

A detailed description of the technical aspects related to the work performed under this contract can be found in the primary STAR reference, “The Scientific Tools for Analysis Research – Data Analysis and Technical Manual”. This document provides details, such as the algorithms used to perform the various analysis measurements, and documents the analysis process used to process and analyze the data for this call-up. The same process can be used for all work with STAR and it can offer significant improvements in efficiency, if followed. A soft copy of the most recent version of the document can be found in draft form in the distribution directory under `acoustics/doc/analysis_tools/STAR_analysis_technical_manual.doc`.

### 3. Data Content

This section summarizes content of the trial data. Detailed processing results have been provided electronically, as the dataset is much too large to efficiently format and publish in a report. The SA and project manager agreed that attempting to reformat results into a report would not be a productive use of contract funds. Detailed information on which sonobuoy types were recorded and where they were located is available from the SA.

Table 2 summarizes the data transcribed from Exabyte tape. Note that one event was copied from CD and several tapes had read errors. The duration of the successfully transcribed data is also provided.

**Table 2. Data Summary**

FILE NAME:	FILE DURATION (MINUTES):	NOTES:
f1s1_dec18.dat	61.311886	OK
f1s2_dec18.dat	60.551907	Bad Date and Time – patched with 18 Dec 95 12:00:00
f1s3_dec18.dat	60.791353	OK
f1s4_dec18.dat	60.531086	OK
f2s1_jan18.dat	60.093838	OK
f2s2_jan18.dat	59.979321	OK
f2s3_jan18.dat	60.378396	OK
f2s4_jan18.dat	60.857287	OK
f3s1_feb21.dat	59.802339	OK
f3s2_Feb21.dat	50.033664	I/O Error after 564M
f3s3_Feb21.dat	61.391701	OK
f3s4_Feb21.dat	59.948089	OK
f4s1_Mar14.dat	59.909916	OK
f4s2_Mar14.dat	59.875214	OK
f4s3_Mar14.dat	48.909312	OK
f4s4_Mar14.dat	60.492913	OK
f5s1_Apr30.dat	60.669895	OK
f5s2_Apr30.dat	60.978745	OK
f5s3_Apr30.dat	60.208355	OK
f5s4_Apr30.dat	60.878108	OK
f6s1_Jun05.dat	60.923221	OK
f6s2_Jun05.dat	60.888519	OK
f6s3_Jun05.dat	60.860757	OK
f6s4_Jun05.dat	60.211825	OK

**Table 2. Data Summary**

<b>FILE NAME:</b>	<b>FILE DURATION (MINUTES):</b>	<b>NOTES:</b>
f7s1_Jul04b.dat	58.000036	OK – from CD
f7s2_Jul04b.dat	40.091477	OK – from CD
f7s3_Jul04b.dat	58.000036	OK – from CD
f7s4_Jul04b.dat	58.000036	OK – from CD
f8s1_Jul29.dat	60.149361	OK
f8s2_Jul29.dat	60.367985	OK
f8s3_Jul29.dat	60.191004	OK
f8s4_Jul29.dat	60.104249	OK
f9s1_Aug21.dat	60.066076	OK
f9s2_Aug21.dat	60.111189	OK
f9s3_Aug21.dat	61.971228	OK
f9s4_Aug21.dat	60.225706	OK
f10s1_Oct30.dat	48.940544	I/O Error – 551M
f10s2_Oct30.dat	50.241877	I/O Error – 566M
f10s3_Oct30.dat	59.382442	OK
f10s4_Oct30.dat	60.111189	OK
f11s1_Nov04.dat	60.399217	OK
f11s2_Nov04.dat	60.329813	OK
f11s3_Nov04.dat	60.28817	OK
f11s4_Nov04.dat	70.296291	OK
f12s1_Dec10.dat	60.2847	OK
f12s2_Dec10.dat	60.555377	OK
f12s3_Dec10.dat	60.173653	OK
f12s4_Dec10.dat	49.985081	OK

## 4. Maintain Configuration Management

---

STAR and SPPACS are maintained using CVS. The most recent release version is maintained and bug fixes are applied to that version, as required, ensuring that a stable release is always available. Simultaneously, software enhancements are applied to the development version and bug fixes are merged with this version. Once a call-up nears completion, or a release of the software is otherwise required, a new release version is branched off of the development stream for final integration, release testing and delivery.

STAR (includes SPPACS) release 4.7.0 (tag `star_release_4_7_0`) was created under this contract to serve as a baseline while the analysis work was being conducted. This allows development to continue on a code branch, while ensuring that stable software is available to users. The branch usually contains newly implemented software, which may not be stable enough to allow for operational use.

## 5. Track Software Issues

Defect Tracking Systems allow users to keep track of outstanding bugs in their product effectively. STAR and SPPACS issue tracking is performed using a web accessible tool called Bugzilla. This tool can be accessed using a secure web interface at <https://star.iotek.ns.ca>. Once the appropriate security procedures, detailed on the web page, have been followed, users and developers can use this site to add, view or modify issues related to the software packages. If required, the Environmental Acoustic Data Acquisition (EADAQ) and Noise Monitoring Software packages can also be added to the site.

None of the current bugs affect this call-up.

A breakdown of the current issues for the STAR and SPPACS distributions are shown in Table 3. The total number of unresolved issues is shown in the NEW/ASSIGNED/ REOPENED column. The total number of opened issues is broken into two classes of severity. Issues classified as BLOCKER/CRITICAL/MAJOR are issues that should be addressed in the short term. Blockers are always addressed immediately to ensure that the user community can continue with their work. Issues classified as NORMAL/ MINOR/TRIVIAL are issues that can be dealt with in the long term.

*Table 3. Distribution Issue Summary (29/03/2005)*

PRODUCT	NEW/ASSIGNED/ REOPENED (TOTAL)	BLOCKER/CRITICAL/ MAJOR	NORMAL/MINOR/ TRIVIAL
SPPACS	39	1	38
STAR	78	4	74

The following gives a more detailed description of the SPPACS BLOCKER/ CRITICAL/MAJOR column:

- Issue # 284 (major) **fails DAT32 byteswap case**. The utility is attempting to read the extra gains using the original header, which may be in a different byte-order than the platform.

The following list gives a more detailed description of the STAR BLOCKER/ CRITICAL/MAJOR column:

- Issue # 193 (critical) **tacplot does not cleanup before exiting**. The work around for this issue is to run `heap_gc` after the analysis window has closed.
- Issue # 107 (major) **problems capturing close button**. A solution exists for this but has only been incorporated into the tactical plot.

- Issue # 295 (major) **capture screen doesn't work correctly.** The Capture Screen button does a screen capture on the analysis window and not the tactical plot. If the tactical plot is closed and reopened this will work. A fix is available in the next release.
- Issue # 329 (major) **overlays need to be optimized.** The tactical plot is too slow (on bender). To load on Bender (dual P4- 1 GHz), it takes approximately 20 seconds the first time and 15-20 seconds thereafter.

## 6. References

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1. The Software Tools for Analysis Research – Data Analysis and Technical Manual – Revision 1/0,  
(/usr/local/atools/acoustics/src/analysis\_tools/documents/STAR\_analysis\_technical\_manual.doc) STAR Release 4.5.1

## List of symbols/abbreviations/acronyms/initialisms

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API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
CVS	Concurrent Versioning System
DIFAR	Directional Frequency Analyzing and Recording
DLT	Digital Linear Tape
DND	Department of National Defence
DRDC	Defence R&D Canada
DREA	Defence Research Establishment Atlantic
DRP	Document Review Panel
EA	Enterprise Architecture
EADAQ	Environmental Acoustic Data Acquisition
FFT	Fast Fourier Transform
FFTW	Fastest Fourier Transform in the West
GUI	Graphical User Interface
HTML	Hypertext Markup Language
IDL	Interactive Data Language
LOFAR	Low Frequency Analysis and Ranging
MDA	MacDonald Dettwiler and Associates Ltd.
NAD	Non-Acoustic Data
PC	Personal Computer



RF	Radio Frequency
RISO	Regional Individual Standing Offer
SA	Scientific Authority
SONLIB	Sonar Library
SPLIB	Signal Processing Library
SPPACS	Signal Processing Packages
STAR	Software Tools for Analysis and Research
USB	Universal Serial Bus
VLA	Vertical Line Array

## **Distribution list**

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This report documents the work done to process EC-SWAN sonobuoy data collected monthly over a 12-month period in late 1995 and 1996. Nine or more sonobuoys were dropped at each of four sites, and included calibrated Low Frequency Analysis and Ranging (LOFAR), Vertical Line Array (VLA) and Directional Frequency Analyzing and Recording (DIFAR) types. The data were processed to determine statistics for use in synthetic sonar data modelling. The data were processed using 8K Fast Fourier Transforms (FFT) and ~4 second incoherent averages. The data sample rate was 6147.5 Hz. Statistics were then computed for five-minute blocks, and averaged to determine the mean statistic over the one-hour sample time. These data are intended to provide a characterization of the probability density functions for ambient noise in Canadian waters that can be used for input to sonar simulation software.

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EC-SWAN  
Sonobuoy  
STAR  
SPPACS

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